

## Soil Flooding and Chemical Alternatives to Methyl Bromide in Tomato Production

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Alternative nonchemical and chemical replacements for methyl bromide (MB) are being explored to find an effective chemical or alternative agricultural practice to control vegetable crop pests. One of the most promising chemical alternatives for MB replacement for tomato production has been a combination of 1,3-Dichloropropene with 17% or 35% chloropicrin (Pic) with the herbicide pebulate (S-propyl butyl(ethyl)thiocarbamate). A nonchemical alternative is the use of flooding as a potential method of controlling pests in the mineral and peat soils of Florida. It has been estimated that approximately as much as 20% of Florida soils are or could be flooded periodically during a portion of the year. In past studies, flooding the soil has been shown to reduce nematode populations in peat and some mineral soils and may suppress weed seed viability and disease. The purpose of this study was to evaluate the effectiveness of off-season flooding for control of pests in tomato (*Lycopersicon esculentum* Mill.) production and to compare its effects against pre-plant fumigants in a mineral soil. The effects of flooding and chemical treatments were evaluated for control of plant disease, root-knot nematode (*Meloidogyne incognita* L.), and nutsedge (*Cyperus* spp.).

A field site consisting of Millhopper fine sand (loamy, siliceous, hyperthermic Grossarenic Paleudults) at the Horticultural Research Unit in Gainesville, Florida was selected for a pre-plant soil flooding and chemical treatment study. The field site was divided into eight sections (16 m x 27 m each) for a randomized split plot design arranged with two mainplot treatments, flooding and nonflooding, and each replicated within four blocks. Flooded plots were managed with an flood-drain-flood schedule of 3 weeks flooding, 5 weeks drying, followed by 3 weeks flooding between 16 Nov. 1998 and 29 Jan. 1999. Soil anaerobic conditions in flooded plots were monitored with oxidation-reduction potential probes and aerobic conditions in adjacent nonflooded plots were determined by measuring water table depth in well points placed to a depth of 0.8 m. All plots were rototilled 2 weeks after each flooding event, and caution was taken to not cross contaminate non-flooded plots with flooded plots with rototiller equipment.

Raised bed rows (0.9 m wide x 15 m long) were shaped and centered within mainplots for subplot chemical treatments and buffer rows. Pre-plant chemical treatments applied on 18 Feb. 1999 included 67% MB + 33% Pic at 392 kg ha<sup>-1</sup>, 1,3-Dichloropropene (1,3-D) with 17% (C-17) and 35% (C-35) Pic at 327 L ha<sup>-1</sup> plus 4.5 kg ha<sup>-1</sup> pebulate (Peb), metam-sodium at 300 L ha<sup>-1</sup> plus 1,3-D at 112 L ha<sup>-1</sup> plus 4.5 kg ha<sup>-1</sup> Peb, and an untreated (check) row. Metam-sodium (sodium N-methyldithiocarbamate) and pebulate were sprayed on the soil surface of designated rows and tilled into the rows. Fumigants were injected under black polyethylene mulch (0.038 mm thick) to a depth of 30 cm with 3 chisels spaced 35 cm apart. Drip irrigation tubing was placed at the center of the bed for irrigation and fertigation. On 24 Mar. 1999 'Florida 47' tomato seedlings were transplanted at a spacing of 0.45 m apart. Nutsedge density was determined with the use of a 0.1-m<sup>2</sup> template and placed at random on the drip line side of the

row. Plants were inspected weekly for disease, and moribund or dead plants were brought to the lab for determination of pathogens. Tomatoes were harvested three times, 3 June, 15 June, and 24 June 1999, and fruit separated into size class categories and weighed. After fruit was harvested, six plants per row were dug, and roots were rated for presence of root knot nematodes and root rot caused primarily by *Pythium* spp.

The maintenance of anaerobic soil conditions within the flooded plots was confirmed by oxidation-reduction potentials decreasing from a well oxygenated system (>400 mV) to a fairly constant (-200 mV) reduced potential reading. It took 1-2 weeks before the lowest potential reading stabilized. The oxidation-reduction potential increased to aerobic soil conditions within 4 days after the flooded plots were drained. Adjacent non-flooded plots were aerobic within the plow layer as the water table remained below a depth 0.3 m in water wells.

The growth of nutsedge was prolific in untreated rows and resulted in significantly higher weeds growing through the plastic mulch than the chemical treatments (Table 1). Metam-Na combined with 1,3-D+ pebulate may have actually stimulated nutsedge growth causing significantly greater nutsedge counts than the other fumigant treatments. The 1,3-D plus C-17 or C-35 treatments with Peb showed as good or better nutsedge control as the MB 67-33+Pic treatment. The adequate control of nutsedge by pebulate in the C-17 and C-35 treatments suggests that applying pebulate with metam-Na and 1,3-D may inhibit its herbicidal activity.

Marketable yields of tomatoes were statistically equivalent in MB, C-17, and C-35 treatments, resulting in significantly higher yields than both metam-Na+1,3-D+Peb and untreated treatments (Table 1). The growth of tomato plants in untreated plots, whether flooded or non-flooded prior to transplanting, was suppressed, and they were visually lower in height, vigor, and disease control than the other treated rows. Control of both nematodes and fungal diseases were significantly lower in untreated than chemically treated subplots, as root-knot galling and root rot indices were highest from non-fumigated rows (Table 1). The overall equivalent pest control and fruit yields in 1,3-D plus C-17 or C-35 treatments as compared with MB reconfirm that these chemical combinations may be the appropriate replacement for MB in Florida tomato production. The lower yields in the metam-Na+1,3D+Peb suggest that this cocktail mixture will not be a good candidate for replacing MB in polyethylene mulch tomato production. Note that the metam-Na+1,3-D+Peb treatment resulted in nematode and root disease control as good as that of the other chemical treatments. This suggests that the decreased yield observed in the metam-Na+1,3-D+Peb treatment is most likely due to its poor ability to inhibit nutsedge growth.

The highest amount of nutsedge was observed in the non-flooded control rows and the thick density of nutsedge most likely contributed to decreased growth rate and high susceptibility to disease. The high density of nutsedge species in the flooded control rows confirms that nutsedge is well adapted to flooded conditions. In fact, during the flooding event nutsedge was observed to grow underneath the water. These results suggest that control of nutsedge may have to include herbicide use to obtain yields similar to that under MB fumigation.

Pest control and tomato yield results between the flooded and non-flooded check plots were not found to be statistically different at the 95% confidence level. However, the average values suggest that soil flooding may have an influence on nematode and some nutsedge control as nematode gall indices and nutsedge densities were lower overall in the flooded than the non-flooded plots. The method of flooding in this experiment may have hindered the true potential of flooding on nematode control as water was continuously applied throughout each flooding event. Flooding the soil with a static head of water may result in better pest control differences as have been observed in muck and high water table soils.

Table 1. Nutsedge density counts, marketable tomato fruit yields, root-knot nematode root-gall ratings, and root-rot disease ratings as influenced by off-season flooding and pre-plant fumigant and herbicide treatments during a Winter 1998 to Spring 1999 study at Gainesville, FL.

<u>Mainplot</u>		<u>Mark. yield (t/ha)</u>			<u>Nutsedge no.per 0.1</u>			<u>Nematode gall index<sup>x</sup></u>			<u>Root Rot index<sup>y</sup></u>		
Not Flooded		38.8			6.4			1.9			1.7		
Flooded		34.9			3.1			1.4			1.6		
Significance		NS			NS			NS			NS		
<u>Subplot<sup>z</sup></u> <u>Treatment</u>	<u>Rate/ha</u>	<u>NF</u>	<u>F</u>	<u>Ave</u>	<u>NF</u>	<u>F</u>	<u>Ave</u>	<u>NF</u>	<u>F</u>	<u>Ave</u>	<u>NF</u>	<u>F</u>	<u>Ave</u>
Untreated	0	25c	31c	28c	21.8a	9.5a	15.7	6.4a	4.8a	5.6a	3.0a	2.7a	2.8a
MB-Pic 67-33	392 kg	52a	51a	52a	1.6c	1.2c	1.4b	1.0b	1.3b	1.1b	1.5b	1.4bc	1.4b
1,3-D+17%Pic+Peb	327 L + 4.5 kg	49a	49ab	49a	1.3c	2.9c	2.1b	1.5b	1.0b	1.2b	1.6b	1.8b	1.7b
1,3-D+35%Pic+Peb	327 L + 4.5 kg	47a	47ab	47a	0.7c	0.7c	0.7c	0.8b	2.0b	1.4b	1.4b	1.8b	1.6b
Met-Na+1,3-D+Peb	300L+112L+4.5 kg	37b	41bc	39b	12.0b	3.8b	7.9b	1.0b	0.9b	0.9b	1.6b	1.4bc	1.5b

<sup>z</sup>Subplot treatment legend: MB=methyl bromide, Pic=chloropicrin, 1,3-D=1,3 dichloropropene, Peb=pebulate, and met-Na=metam sodium  
NF=not flooded, F=Flooded, Ave=Average of NF and F.

<sup>y</sup>Root rot indices of 1-5 with 1=<10% rot, 2=10-25%, 3=25-75%, 4=75-100% of root system diseased, and 5=dead roots.  
(root rot was caused predominantly by *Pythium aphanidermatum* or *P. myriotylum*).

<sup>x</sup>Root knot gall indices 0-10 with 0=no galls, 1=1-10%, 2=11-20%,...,and 10=100% of root system galled.  
Mean separation within columns by Duncan's multiple range test, P=0.05